CHICAGO NEUROLOGICAL SOCIETY.

December 19, 1901.

The President, Dr. Hugh T. Patrick, in the chair.

The Relations of the Areas of the Various Levels of the Spinal Cord in Cross Section.—As a result of studies made in the laboratory of the University of Chicago by Mr. Davis concerning the relations of the areas of the various levels of the spinal cord in cross section, Dr. Donaldson made the following report. He said that a number of spinal cords had been examined and an average length obtained. With this average length as a base line curved lines were drawn in a parallel direction representing first the variation from it produced by tracings of the spinal enlargements, and second variations from it produced by tracings from the axial lines of the gray and white matter. In other words, curvilinear lines were drawn in the same direction as the base line, showing the relations of various levels of the cord *in toto* and also the relations of sections of the gray and white matter in progress through the cord.

The old plat which appeared in Quain's Anatomy and other textbooks was copied from the original work done by Stilling. His chart was made from sections of a five-year-old child's cord. It has appeared in the literature since 1874 without mention of the fact that the chart was made as indicated. As yet no comparison can be made between the child and the adult cord as the work is too new.

The claim is made for this sort of work that by a comparison of the area of the cross section of any given spinal cord with the corresponding area of the standardized cord knowledge might be had as to the condition of the cord compared with the normal.

Dr. Hugh T. Patrick inquired whether a piece of foil cut out to correspond to the gray matter was used as the basis of measurement.

Dr. H. H. Donaldson said that the section was first enlarged about four times, the outline then drawn on tracing paper which is placed over the foil, which is cut in accordance with the figure. From that figure the calculation is made. The foil used for this purpose must be of uniform thickness so that the measurements will be accurate. The foil is sold in strips and as the ends of the strip are much thinner than the middle piece, only the latter is used. These strips are all weighed so that they will correspond to the standard. The measurements can also be made with cardboard.

Dr. Hugh T. Patrick thought that this subect was of some practical importance in some of the degenerate diseases, especially cerebellar ataxia, in which the central nervous system has been found very small. He could not recollect any statement bearing on the small amount of white or gray matter, but simply recalled mention of the small size of the brain, the cerebellum, pons, medulla oblongata and cord. In one case measurements of the cord were given in different diameters. He was of the opinion that in connection with some of the congenital diseases these comparative measurements might be of considerable interest.

Dr. H. H. Donaldson saw a possible use for these measurements in the conditions mentioned by Dr. Patrick. It would enable one to state how much a given section deviated from the standard. He said that although the total area of white and gray matter might be a little larger or smaller, the relative development was very well maintained.

Dr. L. F. Barker inquired as to the kinds of reproductions in Stilling's Atlas.

Dr. H. H. Donaldson said they were lithographs and were probably pretty accurate. The cross sections of the cord were placed in cells filled with alcohol. The observations were made while the specimens were in a good state of preservation, before the alcohol had shrunken them.

On Growth Changes in the Ganglion Cells and Dorsal Root Fibers from Different Segments of the Spinal Cord.—This paper was read by Dr. H. H. Donaldson. Dr. Donaldson said that the results presented were based on work which had been done in the laboratory by Mr. Hatai, who is a fellow in the department, and who, at Dr. Donaldson's suggestion, undertook a study of the growth changes in a certain class of nerve cells. This class being the cells constituting the dorsal ganglia of the spinal cord.

The animal used was the white rat. Ganglia were taken from three different segments of the cord of each animal used. The ganglia examined were the sixth cervical, the fourth thoracic, and the second lumbar. The animals selected for study were four in number. The weight of the animals was ten grams, twenty-four grams, sixty-eight grams, and one hundred and sixty-seven grams, respectively. The ten gram rat was about five to eight days of age. The largest, about six or seven months old. At about the sixth month rats begin to reproduce, so that the largest one had already reached the age of reproduction. We have then spanned between the smallest of these rats and the largest concerned a period extending from shortly after birth to maturity. In each of these animals three spinal ganglia and the connected dorsal nerves were examined.

The first point investigated was this: Is the number of the nerve cells constituting a spinal ganglion constant from birth to maturity? The figures which were obtained for the cervical ganglion were as follows: In the rat weighing ten grams there was found something over ten thousand of these cells. In the rat weighing twenty-four grams, over nine thousand cells. In the sixty-eight gram rat, over twelve thousand, and in the hundred and sixty-seven gram rat over eleven thousand.

The differences in these numbers were interpreted as individual variations occurring in the number of cells in spinal ganglia in which there is no decrease or increase,—that is in the sense of production of new cells,—during the growing period. Dr. Donaldson thought it might be fairly inferred from these observations that the number of spinal ganglion cells remains constant during this period. That is an important point to settle. This statement is not, however, equivalent to a statement that no changes are taking place in these ganglion cells during this period. As a matter of fact all the cells are growing, that is, increasing in size.

Furthermore, the recent studies of Hatai on the spinal ganglion cells have shown that there are two classes of cells. They may be divided into the small and the large cells. Under these circumstances it was of interest to determine whether the relative number of small cells was the same at maturity as at birth. So as not to overburden his hearers with this mass of figures, Dr. Donaldson used simply those for the sixth cervical region in a diagram which showed the ratio of large to small cells. There was in this ganglion a certain number of small cells and large cells which footed up to the total. Dr. Donaldson called attention to the fact that these numbers are variable, the large cells steadily increasing in number, whereas the small cells drop off in number as the rat increases in weight. Thus, if we make a ratio of the small cells to the large cells, we find that in the youngest rat there are something over 3.4 small cells for every large one. At the next stage three small cells for every large one, at the third, two and three-tenths cells for each large cell, and in the last rat one and four-tenths cells for every large one. In other words, with the increase in age of the animal the number of small cells steadily diminishes and the number of large cells is correspondingly increased.

In the ganglia of the thoracic and lumbar regions the same changes occur. The next point touches the number of nerve fibers in the dorsal nerve roots. Our usual representation of the spinal ganglia is to draw a single ganglion cell on the board and ask our audience to multiply this unit and make a ganglion of it. This typical ganglion cell always has two branches, one of which passes to the spinal cord, as the dorsal nerve root fiber, and the other towards the periphery, in the peripheral nerve. If this completely represented the structure of the ganglion then we should have as many fibers in the dorsal nerve root as we have cell bodies in the spinal ganglion, because each ganglion cell giving rise to one branch forming the dorsal nerve root fiber would be represented in the root by one fiber, and in the ganglion by one cell body. From studies, both on mammals and on frogs, we know that every time the attempt has been made to determine the relation between the number of cells in the ganglion and the number of fibers in the root, there has been found a large excess of ganglion cells in the ganglia. Observations were then directed to finding out the exact relationship between the two.

The total number of the dorsal root fibers was shown in a diagram for the cervical, thoracic and lumbar nerves. Dr. Donaldson said that in the cervical root the number when smallest was 1,998, increasing to 4,227 when largest, and the same thing appears in each one of the other columns. Thus if you take a rat of ten grams, he will have in this locality 1,998 fibers for that particular dorsal nerve root, whereas a mature rat has 4,227 fibers in the same nerve root. In other words, the number of fibers in the dorsal root has materially increased, between the ten gram stage and 167 gram stage. This is a new point as regards the mammal. As a frog grows larger the fibers in the dorsal nerve root increase in number. Thus while it has been known for a long time that this takes place in the frog, it is new to the mammal, but if it holds good in the frog and in the rat it will most probably hold good in man. In the rat at birth, then, we have one fiber where at maturity there is something over two. In the thoracic region we find one fiber at birth to two and a half at maturity, and in the lumbar nerve one fiber at birth to two and one-tenth at maturity. It holds good then in all of the different levels that the number of fibers is at first small and steadily increases as the rat grows larger. The suggestion at once arises that we may associate this increase in the number of fibers with the increase in the number of large nerve-cells in this ganglion. In the cervical region the number of fibers is nearly equal to the number of large cells. It is 1 fiber to 1.2 large cells; 1.092, 1.097, and 1.1 for the four rats chosen.

In the thoracic and lumbar regions there are nearly twice as many of the large cells as there are fibers, so that according to this observation the cervical differs from the thoracic and the lumbar ganglia in this relation of the number of the large cells to the number of fibers. The ganglia are differently constituted.

Now to return to a consideration of the number of cells in the young ganglia as compared with the number of fibers in the corresponding dorsal root, and the relation of these two during the growth process. For every fiber in the cervical dorsal root there are at birth 5.5 cells, which number gradually diminishes until it drops down to 2.7 cells at maturity. Not half the cells are in commission, in the sense of furnishing dorsal root fibers, in the cervical ganglion of the mature rat. The discrepancy is much more marked in the thoracic and lumbar regions. They start with 11 cells to every fiber and end up with about 5 cells; ending where the cervical began. In every instance there is a tendency for the cervical ganglion to be precocious and more complete in its development.

We have then verified completely the fact of the excessive number of cells in the spinal ganglia. We have shown that that excessive number decreases gradually as the number of nerve fibers in the dorsal root increases with the growth of the young, and that at maturity there are in the rat anywhere from 2.7 to 5.7 cells in a spinal ganglion for every fiber that exists in the dorsal nerve root.

These are the principal points which Dr. Donaldson wanted to make evident although others were shown on the diagram, but they did not bear on these two fundamental points. First, the constancy of the number of nerve cells in the spinal ganglion throughout life. Second, the progressive increase of the number of nerve fibers in a dorsal nerve root. Third, the disparity between the number of fibers and the number of cells, that for the fibers standing to that for the cells as 1 to 2.7 or 5.7 in the several cases.

Dr. Donaldson spoke as to the possible application of these results. They were also studying the activity and growth of intelligence in the rats. They found that rats which are of about this weight, 24 grams, and which have therefore about one-half the total number of nerve fibers they are destined to have in a dorsal nerve root, are the most active. When they get larger they become slow and comparatively inactive. In other words, as far as this particular animal is concerned, the very active period is correlated with the period in which the afferent roots are only half completed. The animal has still to double the number of nerve fibers in the dorsal root, and while that is going on it becomes a much less active animal than it was in the early stage.

Dr. Donaldson believed there is every probability that this condition of things will be found to obtain in man. They had no spinal cords at present to work on and hence are blocked in their studies. Although it is impossible at the moment to correlate these periods of development with the period of development in the growing child, he would say that between 25 and 68, somewhere about 30 or 40 grams would correspond to a six or seven-year-old child. If the relations in the development of the nervous system are the same, we would then find the child with incomplete dorsal nerve roots at a time when it is about as active as it ever will be. The settlement of this question must await the appearance of suitable material.

Dr. L. F. Barker regretted that Dr. Donaldson did not divulge his opinions based on the results of this work. Naturally a great many questions arise. He was especially interested in getting an explanation of the reason for the increase in the number of fibers. Three possible explanations suggest themselves. One, the growing-out of more fibers from the cells in the ganglion to the cord, probably the most likely explanation. The second possibility would be a division of single fibers already present, and the third an outgrowth of fibers from the cord to the ganglion, although that might be the least plausible.

The second point was the disappearance of so many of the small cells, the increase in the large cells, which apparently was due to the development of the small cells. Nevertheless there are in all cases a large number of small cells left undeveloped. He said he would like to know whether these were surplus cells that never attained to maturity, remaining small cells without any processes, or whether they possibly can be cells which send out axis cylinders to end in cell bodies of other neurones. If they remain immature it would be in accord with what is believed to occur elsewhere in the nervous system, namely, that in all parts of the nervous system, as in most parts of the body, there are cells left in an immature state capable of further development under certain circumstances. If that is the case there are as many reserve cells in the ganglia as there are cells in commission. That would be a very large excess of reserve cells, but if it is remembered that as in the substantia gelatinosa many cells develop and degenerate, as many as attain maturity, the excess would not seem so great. He also asked for the reason of the increase in the ratio of fibers to cells, especially in the cervical region. Naturally the first thing to which attention would be directed is the possibility of the enormous development of the hand as a sense organ as compared with the thoracic region, and the lower extremity as a sense organ. He did not know whether in the rat the hand was more of a sense organ than the foot. In the human being we might naturally expect a greater number of root fibers in the cervical roots than in the thoracic or lumbar. The hand area in the cerebral cortex is very large compared with the trunk or foot area. Another point, that this change in proportion takes place during the point of greatest activity of the animal, is extremely interesting, and suggests the possibility of a relationship between activity and development. It is a well-known fact that the exposure to strong light of prematurely-born cats increases the rapidity of development of the myelin sheath. Why could it not be possible that the further activity should determine this rapid change in the ratio of fibers to cells? He hoped that Dr. Donaldson would explain these points.

Dr. Donaldson said that we might account for the increase in the number of fibers in the dorsal nerve root by assuming that the new dorsal root fibers grow out from cells which entered into commission in the later stage of the ganglion, being immature in the early stage. That explanation receives its best support from the relation in the cervical region between the large cells and the number of fibers. In the dorsal nerve root the number of large cells is equal to the number of nerve fibers. The division of fibers does not appear so probable in the sense in which it would have to take place, although many of the fibers are divided. These divided fibers all pass to the periphery, but such a division has always been observed at a stated place, the dividing branches being of equal length and equal growth, and do not simply represent a series of twigs which might run out and thus add to the number of fibers. All the evidence tends to point toward the throwing into commission of new cells for the addition of new fibers to the dorsal nerve root.

The next question, as to the excessive number of cells in the spinal ganglia, he deemed a rather hard nut to crack. There were a few cells, the axones of which ended within the limits of the spinal ganglion itself. These, however, are few in number and cannot account for the very large apparent excess of the cells in the ganglia. The excess will probably be found to be due to the immature cells which have not yet sent their axones out any great distance. The higher one goes in the nervous system, the greater appears to be the excess of cells found in the different localities. In man the excess is probably much greater than in the frog or rat. That is a rather dangerous thing to say because it is in the nature of a prophecy. However it does not appear to be impracticable. It is rather difficult to say what is the function of these cells and yet there appear to be many of them in the cortex and there is no reason why they should not appear in the spinal ganglia. It seems to be a property of the nervous system to contain more parts than it actually needs and lives up to.

As to the difference between the number of fibers and the number of cells in the thoracic and lumbar regions as compared with the cervical region, he believed that possibly the sympathetic nerves have something to do with this. He said his first impulse was to associate the excessive number of cells in the thoracic region with the sympathetic connection which is absent in the cervical. This, however, is but a poor explanation, as it is open to question. As to use and disuse, something might be made out of that suggestion, even though there is nothing at present that would bear directly on this. He suggested that rats might be brought up in loneliness and solitude where activity would be reduced to a minimum, and then be compared with rats brought up in playful activity, so as to determine whether there is any difference in the development of the spinal ganglion cells.

Dr. Hugh T. Patrick inquired whether the fibers in the brain had ever been counted. Whether there is a great increase in the fibers with the mental and intellectual development of the individual, or whether they simply take on sheaths. Whether the corpus callosum at birth contains more fibers than in the adult.

Dr. Donaldson said that he had found the fibers present, but they did not have any medullary sheaths. The cell-bodies might be present, he said, but not their axones. He felt that the axones are a later growth in a large number of the cell elements. These observations have been made only from the standpoint of medullation, showing the increase in medullation as maturity is reached. He was positive that the axones are not present in rats. The rat's cerebrum can be cut very deeply and a few weeks later it is impossible to find the scar. The wound grows over completely, because the brain is cut at a time when most cell elements are in a neuroblast stage. There are no axones. For that reason it is difficult to find the place of injury.

Dr. J. W. Engbert said that from comparative anatomy and biology it has been ascertained that the cord at one time had different segments which seemed to be more or less similar. In man it is found that certain segments gain a great deal, as, for instance, the cervical and lumbar, whereas the thoracic loses. In what does the gain consist? Do the segments gain chiefly in cell bodies, or do they send out fibers?

Dr. Donaldson said that in the gray substance, where it is voluminous, there is an excessive number of cells. There is also an excessive number of fibers as is shown by the rise in the curve in the white substance coincident with the enlargement of the gray. The white substance is distributed both around the gray matter and within it. In the lumbar region the gray matter is comparatively less than the cervical enlargement, and in that sense the smallness of this segment is really a reduction in the amount of white matter in it. It is accomplished by change in the shape of the cells. They lie like watermelons, on end, in the thoracic region; on their side in the cervical; and in the lumbar region as if they were set on their side with the widest plane in the plane of this section. They have different shapes according to the segments in which they are located. Though the segments are short in the lumbar region the amount of gray matter is as large as in the cervical segment.

Dr. L. F. Barker asked if the base lines were made so that the segment distances were equal, how, then, would the gray matter lie.

Dr. Donaldson said that the vertical length would have to be multiplied by the horizontal length, and the difference in the area exaggerated by making the segments equal. There is a relative increase of gray matter in the two enlargements when reduced to cubic contents.

March 20, 1902.

The President, Dr. Daniel R. Brower, in the chair.

A Case of Hysteria.—Dr. Elbert Wing reported the case of Miss H., aged fifteen years, who complained of a constant ache in all of the teeth of the upper jaw, accompanied by tenderness in all of them; both the aching and tenderness being greatest on the right side. The pain is described as a dull, heavy ache, rather than sharp, cutting or lancinating, varies somewhat in severity, and is present all of her waking hours. The tenderness is not great and not uniform in all of the teeth. The pain is influenced somewhat by cold, but not at all by heat. It is not increased by the acts of talking or eating. In May, 1901, the patient had an attack similar to this, in which the teeth of the lower jaw were involved. It began in a few of the teeth on the left side. Dr. F., her dentist, drilled into these, destroyed the pulps, and filled the root canals. This did not stop the pain, and finally the affected teeth were extracted. This treatment with variations ran the circuit of her lower jaw, until all of its teeth were extracted, and a plate of artificial teeth put in. About six weeks after the teeth were all extracted, the pain, diminishing gradually, ceased. Six weeks after all pain ceased in the lower jaw, it began in the teeth of the right side of the upper jaw, and had continued until this examination was made, December 21, 1901. The dentist did not excavate or extract the upper teeth.

Three years ago the patient had what she described as "soreness in her scalp," which was not relieved until her hair was cut short. Then she had some trouble with her eyes, not inflammatory, in which she says she "almost lost her sight." Later she had attacks of spasms. She says that one doctor stuck pins in her and said that "there was nothing the matter with her." She has had no other illness, and menstruation is fully established, regular and normal in every way.

The patient's father has had "nervous trouble," is now well, and the family history is otherwise negative.

Examination shows a young woman, five feet eight inches tall, large in proportion, in excellent general nutrition, and full mammary development. Appetite good; no symptoms of indigestion; bowels act normally, and sleep is good, except when disturbed by the pain in the teeth. Loss of sleep from this cause, she says, is considerable. Patient's appearance is that of excellent health. When alone with the examiner the patient's manner is quiet and free from peculiarity, except lounging in her chair, but when her dentist, who seems familiarly acquainted, is present, her manner is petulant and capricious. The thoracic and abdominal organs are normal.

Voluntary motor power is normal and symmetrical. Tests for touch and pain were made with camel's hair brush, and common pin. Sensation to touch is slightly less throughout the left side. On this side there are areas of moderate size of diminished sensation over the upper half of the chest, the hypochondriac region, the outer and middle third of the thigh, and two places on the leg. There is absence of pain to the prick of a pin over and just above the left breast, and there is diminished pain sense in the areas partially anesthetic to touch, and slight anesthesia over the left scapula. Epigastric reflex is slightly less on left side; abdominal walls symmetrical; elbow-jerks are absent; knee-jerks are present and fairly symmetrical. The pupils react normally, and vesical and rectal control are reported normal. There is moderate tenderness in the upper teeth, more pronounced on the right side, and some in the upper branch of the fifth nerve of the right side. There is no other tenderness. Physical examination is not carried further. The patient was referred to her home physician with the diagnosis of hysteria and the usual outlined suggestions for treatment.

Dr. Harold N. Moyer asked whether the patient had a mania for operations, to which Dr. Wing replied: "It would seem so."

Dr. Charles L. Lodor inquired whether there were any anesthesia of the mouth.

Dr. Wing replied that there was not.

Dr. Lodor asked whether the teeth were sensitive or not.

Dr. Wing replied that they were not.

Dr. Sydney Kuh recalled the case of a girl who presented herself at Czerny's clinic in Heidelberg, with the statement that she had swallowed a pin. She had considerable pain; her stomach was opened, and a pin was found in the wall of the stomach. The patient returned subsequently two or three times, wanting to undergo another operation. The suspicion of the surgeon was aroused; he refused to operate a second time as he was firmly convinced there were no more pins in the stomach.

Dr. Kuh also detailed a case of hysterical deception which occurred in the practice of a country doctor. The country practitioner sent the specimen to Dr. Edmund Andrews for examination, with a history that the girl had swallowed a snake, that she could feel it moving about in the abdomen, and insisted that something be done for its removal. But little or no attention was paid to her until one day they found her in front of the house quite ill apparently. She had vomited and in the vomit there was a snake-like body, which was sent to Dr. Andrews for analysis, and it turned out to be the gut of some animal.

Dr. Daniel R. Brower mentioned a case which occurred in the practice of Dr. Fitch many years ago. It was stated that the woman's urinary secretion had been entirely suppressed, and that she was secreting urine by the gastric mucous membrane. He was called in consultation in this case. Dr. Fitch had the contents of the woman's stomach examined a number of times, and always found urine in the contents. He suggested to Dr. Fitch that she be put to bed and some responsible person be directed to watch her. This was done, and it was found that the woman would urinate, and then swallow the urine.

Dr. Lodor referred to a patient who had some of her teeth extracted on account of a supposedly distressing condition of them. She exhibited the usual stigmata of hysteria. She was referred to him with the recommendation that the dental nerve be trephined for excessive pain; but on examination he found nothing wrong with the patient's mouth, and said the case was purely hysterical.